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APPLICATION FOR PATENT
FOR
MAIN BODY OF EXPLOSIVE COMPOSITION

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PATENT
584-27777 US (102.40)

RELATED APPLICATIONS

This application claims priority from co-pending U.S. Provisional Application No. 60/408,242, filed September 5, 2002, the full disclosure of which is hereby incorporated by reference herein.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to the field of explosive compositions. More specifically, the present invention relates to a combination of explosive where the combination possesses operating characteristics that are superior to the constituent components of the combination.

2. Description of Related Art

Explosive compositions, also known as high explosives, are used in a variety of industrial applications including mining, military ordinance, car safety bags, general pyrotechnic applications, and in the production of hydrocarbons. One of the predominate uses of high explosives in some ordinance applications and in hydrocarbon production is in conjunction with shaped charge perforating devices. With respect to hydrocarbon production, shaped charges are used to perforate the casing circumscribing the oil/gas well bore, the cement around the casing, and the surrounding formation. The resulting perforation produces a pathway for hydrocarbons contained within geological formations to travel into the well bore and ultimately to the well head.

Shaped charges used for well bore perforating are generally affixed within a cylindrical gun tube which is then inserted within a gun body. Often many gun tubes are axially connected

to form a perforating string. Depending on the particular application, each gun tube typically contains multiple shaped charges within its circumference that are aligned to discharge radially outward from the gun body. The outer diameter of the gun tubes can range from less than 1.5 inches to almost 5 inches. The combination of gun tube within a gun body is generally referred to as a perforating gun. In use, the perforating gun is attached to a wireline and inserted into the well bore. The wireline generally provides a tethering support for the perforating gun while it is within the well bore; it also is a conduit for electrical signals to be provided from the surface to the perforating gun to detonate the shaped charges.

An individual shaped charge usually comprises a housing, a liner, and explosive positioned between the liner and the housing. The housing is typically formed from high strength metals, such as steel, and has a generally cylindrically cavity formed within which extends from inside of the housing through one of its ends. As is known in the art, explosive material is packed into the cavity and a liner is pressed into the housing with the liner's outer circumference abutting the inner circumference of the housing cavity. This configuration confines the explosive between the liner and the housing cavity. When the explosive within the shaped charge is detonated, the force of the detonation collapses the liner and ejects it from one end of the charge at very high velocity in a pattern called a "jet". The jet penetrates the casing, the cement and a quantity of the formation.

During packaging of the shaped charge, the explosives are pressed into the housing under pressure under a liner. The compressive forces generally range from about 20,000 to about 40,000 pounds force. Typical explosives used include HMX, RDX, TEX, TATB, PYX, HNS, DATB, and PETN. The pressing of the explosive under pressure not only positions the

explosive into the housing, but also compacts the explosive into a more dense form. While physical constraints, such as yield strength of the housing, possible desensitization of the booster charge, or inadvertent detonation of the explosive, limit how much compaction can be applied to the explosives; the explosives are compacted as much as is possible.

Pressure compacting of most explosives into shaped charges results in the pressed density of the explosive being at 85% - 90% of the theoretical mean density of the explosive. Generally pressed density defines the density of a fixed quantity of explosive in particulate form after the explosive has been pressed or compacted. The bulk density of the explosive generally defines the density of the explosive in loose form without the explosive first being subjected to external mechanical forces, such as compaction. Whereas the theoretical mean density of the explosive is the density of explosive in solid form. The magnitudes of the bulk density and press density are always less than the magnitude of the theoretical mean density. This is due to the interstices that exist between the individual particles of explosives, even when the explosive is pressed or compacted. The presence of these interstices, which have a lower density than the explosive, causes the density of the volume of explosive particulate to be lower than the density of a solid piece of explosive.

Explosive particles can be categorized based on their size. One standard for this categorization is found in military standard MIL-DTL-45444C. This standard allocates the particles into a particular class depending on what weight percentage of the particles can pass through specified sieve sizes. The MIL-DTL-45444C classification system is illustrated in Table 1.

Through U.S. Standard Sieve No.	Class I Weight Percent	Class II Weight Percent	Class III Weight Percent	Class IV Weight Percent	Class V Weight Percent	Class VI Weight Percent
8	--	--	--	100	--	--
12	--	--	99 min	85 min	--	99 min
35	--	--	--	25 +/- 15	--	--
50	90 +/- 6	100	40 +/- 15	--	--	90 min
100	50 +/- 10	--	20 +/- 10	15 max	--	65 +/- 15
120	--	98 min	--	--	--	--
200	20 +/- 6	--	10 +/- 10	--	--	30 +/-15
325	8 +/-5	75 min	--	--	98 min	15 +/-10

Table 1. MIL-DTL-45444C Explosive Particle Classification

The classification system of Table 1 is not limited to a single type of explosive, but includes explosives having different chemical compositions. As such, particles of Class 1 HMX have the same size or same size distribution as particles of Class 1 PETN.

As is well understood, increasing the kinetic energy of the jet will in turn result in a larger diameter perforation, or a deeper penetration. Many factors can affect the kinetic energy of the jet, such as the size and type of liner, the size of the shaped charge, the amount of explosive used, or the type of explosive. Often, it is desired to maximize the jet energy in order to obtain either a large diameter perforation or a deep penetration. Increasing the amount of high explosive can in turn increase the jet energy. However, physical dimensional constraints exist that limit the housing capacity, which in turn limits the maximum amount of explosive that can be packed within the housing.

Other physical factors of the explosive can also increase the energy it can impart to the liner upon detonation. It is well known that the dynamic velocity of an explosive is directly proportional to the density of the explosive. It is also known that the dynamic pressure produced during detonation by an explosive is proportional to the square of the explosive density. Accordingly increasing the density of an explosive, or a quantity of explosive particulate, increases the velocity and pressure produced by the explosive during detonation.

Therefore, there exists a need for an explosive whose detonation produces jets having a kinetic energy that is greater than the kinetic energy of jets produced by explosive that is compacted into a shaped charge.

BRIEF SUMMARY OF THE INVENTION

One embodiment of the present invention discloses an explosive material comprising a mix of a first quantity of explosive and a second quantity of explosive. The first quantity of explosive consists of a large particulate size explosive. The second quantity of explosive consists of a small particulate size explosive. The combination of the first and second quantity

of explosives results in an explosive mixture having a density greater than either the first or second quantity of explosive. The explosive material is encapsulated within a bonding agent to form a pelletized explosive. The explosive material can be comprised of approximately 25% to 75% by weight of the first quantity of explosive and approximately 25% to 75% by weight of the second quantity of explosive.

One form of the explosive material has a pressed density that is from approximately 96% to approximately 98% of theoretical mean density of the solid explosive. The first or second quantity of explosive can be selected from the group consisting of HMX, PBX, TATB, PYX, HNS or DATB. With respect to the explosive material, the first quantity of explosive can consists of particles whose diameter ranges from approximately 300 microns to approximately 45 microns. Alternatively, the first quantity of explosive can consist of Class I explosive.

The second quantity of explosive can consist of particles whose diameter ranges from approximately 5 microns to approximately 7 microns. Alternatively, it too can consist of Class V explosive, or can be comprised of a distribution of particles such that 90% of the particles have a diameter of less than 10 microns.

The explosive of the present invention can also be used in combination with a shaped charge, in mining, military ordinance, car safety bags, general pyrotechnic applications, and in the production of hydrocarbons.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING.

Figure 1 illustrates a cross sectional view of a shaped charge having a housing, a liner, and a quantity of high explosive.

DETAILED DESCRIPTION OF THE INVENTION

With reference to the drawing herein, a shaped charge 10 according to one embodiment of the invention is shown in Figure 1. The shaped charge 10 typically includes a generally cylindrically shaped housing 1, which can be formed from steel, ceramic or other material known in the art. A quantity of explosive powder, also known as the main body of explosive 2, is inserted into the interior of the housing 1. A recess 4 formed at the bottom of the housing 1 can contain a booster explosive (not shown) such as pure RDX. The booster explosive, as is understood by those skilled in the art, provides efficient transfer to the main body of explosive 2 of a detonating signal provided by a detonating cord (not shown) that is typically placed in contact with the exterior of the recess 4. The recess 4 can be externally covered with a seal, shown generally at 3.

One embodiment of the present invention considers an explosive formed by mixing two different quantities of explosive, where the particles that make up each of the two different quantities have different diameters. It has been discovered that the pressed density of a quantity of explosive can be increased when the explosive is produced by combining two quantities of explosives, where the particles that make up each of the quantities have different diameters. More specifically, it has been found that a mixture of 50% by weight of Class 1 HMX with 50% by weight of Class 5 HMX results in a body of explosive with a resulting pressed density that is 96% to 98% of the theoretical mean density. This increased pressed density is a vast

improvement over the pressed density of traditionally compacted explosives. Further, a range of mass percentages of a mixture of 25% to 75% of Class I explosive and 25% to 75% of Class V explosive has been found to produce advantageous results. The novel explosive of the present invention possesses a pressed density having a magnitude greater than prior art explosives. Accordingly the explosive of the present invention is capable of producing detonations that have a higher detonation velocity and pressure than explosives having a lower pressed density. Higher detonation velocities and pressures result in the explosive transmitting a greater kinetic energy upon detonation.

One such application of the explosive of the present invention is its use with shaped charges. As such, when the explosive of the present invention is used in conjunction with shaped charges, the liner will exit the shaped charge with more energy to produce larger and deeper penetrations. In turn these larger and deeper penetrations can result in enhanced hydrocarbon production. An added advantage of the present invention is that improved performance can be realized without increasing the amount of explosive within the shaped charge. Accordingly the size of the shaped charges can remain the same while attaining these improved results.

One preferred embodiment of the present invention is a 50% by weight mix of Class I explosive with a 50% by weight of finely divided Class V explosive. Class I explosive has a general range of particles of from approximately 45 microns to approximately 300 microns. Finely divided Class V explosive has a median particle diameter of 5 microns and an average particle size of 5 to 7 microns in diameter. Further, 90% of the particles of the finely divided Class V explosive are less than 10 microns in diameter. The choice of sizes of differing explosive sizes is important in reaching the desired pressed densities. The smaller particles must be able to occupy the interstices that exist between the larger particles. Other embodiments of

the present invention exist as well, such as an explosive comprised of a mix of Class I, Class V, and Class VI and a mix of Class I with Class VI.

While the explosive of the present invention can be used in its particulate or crystalline form, for safety concerns, it is preferred that the explosive be granulated or pelletized prior to its packaging for use. The granulation or pelletizing methods employed can be any that are known in the art, but the methods should involve encapsulating the explosive within a polymeric covering. The preferred method of granulation involves mixing the quantities of explosive having different particle diameters with a fluid (generally de-ionized water) inside of a vessel. The mix of explosive and fluid creates a slurry inside of the vessel.

The explosive particles and fluid are mixed as they are added to the vessel. Generally a mixer is included with the vessel, where the mixer consists of mixing blades, a shaft, and a motor. As is well known, the motor provides rotational energy to the shaft, and rotates the mixing blades within the vessel. With respect to the present invention, the mixing blades work to mix the fluid and explosive particles to create a homogenous slurry. The explosive particles of different class sizes are blended together prior to being added to the vessel. The blending process generally does not involve an agitator, like a mixing blade, but instead is some type of container in which the mix is added and the container is rotated thus mixing together the container contents.

While the slurry is being mixed, it is also being heated to about 70°C (160°F) to about 77°C (170°F). The preferred heating technique employs routing pipes inside of the mixing vessel through which a heated fluid passes. The heated fluid, such as low pressure steam, transfers thermal energy into the slurry. When the explosive mixture reaches the proper temperature set point, as determined by one skilled in the art, a solvent/polymer lacquer is added to the slurry.

As is well known, the lacquer will encapsulate amounts of explosive to form beads that are approximately 1000 microns to approximately 2000 microns in diameter. Encapsulating the explosive works to desensitize the explosive, thereby reducing the likelihood of an unintentional detonation of the explosive. After encapsulation the pelletized explosive can be transported or packaged in its usual manner.

In more detail, the encapsulation process first requires a nucleation step. Nucleation occurs when the explosive particles are drawn together by small attractive forces; where the attractive forces include Van der Walls forces, electromagnetic forces, molecular, and magnetic forces. It is important that the correct ratio of fluid and explosive particle be present in the vessel because if the fluid portion is too large, then the explosive particles will be too far apart and nucleation cannot occur. Conversely, if too much explosive is present, mixing will be hindered and the explosive particles cannot move freely. Many factors determine the proper fluid/explosive ratio, such as particle size, the range and ratio of particle size, and the type of fluid. It is believed that one skilled in the art can determine the proper ration without undue experimentation.

As noted above, when the proper temperature set point is reached, a lacquer is added to the slurry mix. The lacquer is a mix of a polymer (such as VITON®) and a solvent, such as butyl acetate. When the lacquer combines with the slurry mix the polymer separates from the solvent and forms into tiny sheet like members. The sheet like members "float" in the slurry/lacquer mix until they encounter the nucleated explosive particles and wrap around and encapsulate the nucleated particles. This produces an initial granule of from about 5 to 600 microns. These initial granules will in turn be further encapsulated inside of another polymer sheet to create larger granules. This process will perpetuate as long as the temperature inside of

the vessel is held at the proper temperature. Lowering the temperature inside of the vessel can terminate the encapsulation process. The nucleation step is generally terminated by an operator who monitors the nucleation process. Some indicators signaling the nucleation should be terminated are that the outer surface, or skin of the granules be shiny and not tacky. Other indicators are that the fluid is fully separated from the granules and is clear, and that no particle dust be present above the fluid surface. Cooling of the vessel can be achieved by switching the fluid in the heating tubes from steam to cool water.

EXAMPLE

In an exemplary embodiment of the present invention, specific manufacturing equipment was selected in the production of one embodiment of the explosive of the present invention. That equipment includes a minimum 1000 gallon jacketed stainless steel reactor with a vapor tight accessible opening, a glass window, and two openings - one opening for lacquer addition and one opening for process flow addition. It is preferred that the reactor be heated via a hot water supply system instead of being electrically heated. Further, the jacketing system should accommodate cooling as well. The vessel should be designed such that the heat transfer rate is 2.0° C, this applies to heating and cooling of what is contained in the vessel. The reactor should be equipped with a 4.0 inch shaft having a single radial impeller and a single axial impeller. The impeller diameter should not be less than one third of the inside diameter of the reactor. The motor provided to rotate the shaft have a horse power of at least 40 and be able to deliver an impeller tip speed of at least 800 ft/minute. A separation system should be employed to receive the slurry exiting the reactor and separate the solid damp product from the liquid.

After the solid damp product is removed from the slurry mixture it should be dried in a drying room capable of drying over 1000 pounds of product within 24 hours. The drying

temperature should not exceed 80° C. Once dried, the product should be desensitized by the addition of graphite and blended to ensure it is homogenous. The preferable amount of graphite addition is approximately 0.25 percent by weight.

Explosives of smaller particle size require a smaller ignition force to induce combustion. Thus the novel combination of the present invention, due to the dispersion of smaller particles disposed between the larger particles, presents a main body of explosive that is more sensitive to external forces and is more easily detonated than known explosives. This is true even though the combination is encapsulated. To make the explosive safe for transportation purposes, it is desensitized which increases the force necessary to cause detonation. As is well known in the art, the explosive of the present invention can be desensitized with the addition of graphite or other desensitizing agents.

The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes can be made in the details of procedures for accomplishing the desired results. Such as using methylene chloride or acetone as a lacquer solvent. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.